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EXPERIMENTAL INVESTIGATION OF FLEXURAL AND HARDNESS BEHAVIOUR OF HEMP FLAX HYBRID COMPOSITE

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Original Article

ABSTRACT

Composites are nowadays used in automobiles, aerospace and marine engineering applications due to their low cost and less weight. This paper involves the fabrication and testing the flexural and hardness behavior of hemp and flax hybrid composite. In this work, the laminates are prepared by the hand-layup method. Epoxy resin with HY951 hardener is used as the binding agent for fabrication of a hybrid composite. Woven glass fiber (GFRP) layers are used on both sides of the laminate to increase strength and stiffness of the composites. The natural fibers layers are sandwiched between the GFRP layers. The natural fibers have been chosen on the basis of, its strength, low density, degradability and its availability. The result showed that hybrid composite laminate has superior flexural and hardness behavior than other laminates.

KEYWORDS: ***Flax Fiber, Hemp Fiber, Hybrid Composite & Mechanical Testing***

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INTRODUCTION

Flax and hemp fibers have good mechanical properties. Hence, they are used as reinforcements in making composite laminate for automobile applications. Bensadoun et al (1) investigated on the low velocity impact properties of flax composites which shows the longevity and safety of the composites. Two composite matrix flax-epoxy and flax-MAPP were tested and compared. It was found that the energy absorbed by the flax-MAPP was 50 % higher than the flax-epoxy. The flex-epoxy resulted in a strong decrease in properties after impact. Also the use of ductile thermoplastic matrix results in decreased impact area. Bambachet al (2) has investigated on the Geometric optimization and compression design of natural fiber composite structural channel sections. It was carried out by the inclusion of geometric stiffeners which restricts the development of local buckling, creating less slender channel sections with greater compression strength. Compression strengths are compared with steel and timber wall stud strengths. They concluded that the developed composite suitable for residential building applications. The combined plain channel and stiffened channel experimental data cover a broad range of section slenderness values. Heedev Antony et al (3) investigated on the hemp fiber yarns that are detached from taffeta and serge fabrics. Experimental, analytical and numerical analysis was made. They concluded that the study improves

the mechanical properties and the same data can be used for further optimization. Changei Xia et al (4) has fabricated the natural fiber and aluminium sheet hybrid composites. The composites were fabricated using vacuum assisted resin transfer molding (VARTM) process. It was found that this hybrid composite possessed high electromagnetic shielding. They found that introduction of aluminium sheets does not affect the mechanical properties of the hybrid composites. The interracial bonds were found to be strong from the results obtained from the internal bond tests. Kin-tak Lau et al (5) have investigated on the properties of natural fiber composites. It was shown more importance due to the fact of its application in the structural engineering. They found that the natural fiber composites have high moisture content, inconsistence on their properties, poor bonding properties with a polymeric resin (hydrophilic fiber and hydrophobic resin) flammability, uneven dispersion in products, particularly short fiber and swelling effect that may affect the quality of resultant composites. Even though it has some shortcomings, they are the most cost effective in all business sectors. Vijaya Ramnath et al (6, 7) investigated the mechanical behavior abaca – jute hybrid composites with varying proportions and different layering sequence. They found that hybrid composite has good mechanical behavior and also 45^{o} orientation composite has better mechanical strength. Srinivasan, et al (8,15,16) investigated mechanical and thermal Properties of Banana-Flax based Natural Fiber and kenaf- flax fiber composites. Korniejenko et al (9) studied the geopolymer composites reinforced with natural fibers and their mechanical properties. Here, the geopolymer composite is based on fly ash and reinforced with short natural fibers such as coconut, sisal, raffia and cotton. They concluded that the composite with coconut, sisal has good mechanical properties, but a composite with raffia has considerably poor properties. From SEM images, it was found that the natural polymers are less coherent than the artificial ones. It is now the best alternative for Portland cement. Sarifa Aziz et al (10) has experimentally investigated the effect of alkalization and fiber alignment on mechanical and thermal properties of long and random kenaf and hemp fiber. In this work, polyester resin is used as the matrix and the natural fibers are alkalized with 6% NaOH solution. The result shows that the alkalized fibers have significant mechanical properties when it is compared with untreated fibers. Morphological Analysis has been done to observe the internal structure of the composite laminate. The result shows that there is a less fracture observed in hemp polyester composites. Also the treated hemp and kenaf fibers showed the absence of surface impurities which were present in untreated fibers. Summer-scales et al (11) has reviewed the bast fibers those are obtained from outer cell layers of stems of various plants. The fibers are composed primarily of cellulose, which potentially has a high value of Young’s modulus, when compared to man-made synthetic fibers. This paper deals with growth, harvesting and fiber separation techniques which are more suitable to yield fiber of appropriate quality. Various natural fibers like flax, hemp, nettle, jute and kenaf are discussed in detail. The result concluded that the bast fibers have weight specific properties which may be superior to the corresponding properties of glass fiber reinforcement that may be very much suitable for various environmental conditions. Vijaya Ramnath et al (12,13, 14) has experimentally investigated various natural fibers with different fiber orientation and concluded that there is a significant improvement in the mechanical properties thereby it can be used as the alternative materials for various engineering industries. Manickavasagam etal (17 18) investigated abaca and flax reinforced polymer composite.

MATERIALS USED

Flax Fiber

Flax is the one of the strongest fiber among cellulosic natural fibers. It is derived from the bast and it is extracted from the stem of the flax plant. Flax fibers are knitted together into woven form and it is linen yarn for thread. Flax fibers are used for clothing for comfort wear. It is one of the oldest natural fibers among all. It is very soft and flexible.

Hemp Fiber

Hemp fiber is one among bast fiber plant like jute, kenaf, sisal and flax. It is categorized from cellulose fibers. It is one of the strongest and most durable fibers among all categories. Various textile products are processed by this fiber only. It is very easy to blend with other fibers to give more strength and good durability.

Fabrication of Composites

For fabricating the composite laminate, in this paper, a hand lay up method is used. Initially the natural fibers are dried for 24 hours for removal of moisture content and then straightened. Now, the fibers are cut into desired lengths of the required laminate. Initially, the GFRP is placed over the flat plate for easy removal of the composite laminate after completed. The resin (LY556) and hardener (HY 951) is mixed in the ratio of 10:1 for better adhesion of fibers in the composite laminate. The layers of flax, hemp and combination of fibers are arranged alternately to form the corresponding laminate as shown in Table 1. Then they are allowed to dry for 10-12 hours under the weight of 12kg. After the curing period, the weight has removed and laminates are used for testing and for further processing. In this work, three types of laminates are fabricated namely category I which contain hemp fiber, Category II, which contains flax fiber and category III, which contains both hemp and flax fiber as shown in table 1.

Table 1: Arrangement of Fibers

Category 1	Category II	Category III
Hemp Fiber (0^{o})	Flax Fiber (0^{o})	
Hemp Fiber (90^{o})	Flax Fiber (90^{o})	Flax Fiber (90^{o})
Glass Fiber	Glass Fiber	Glass Fiber
Hemp Fiber (45^{o})	Flax Fiber (45^{o})	Hemp Fiber (45^{o})
Glass Fiber	Glass Fiber	Glass Fiber
Hemp Fiber (90^{o})	Flax Fiber (90^{o})	Flax Fiber (90^{o})
Hemp Fiber (0^{o})	Flax Fiber (0^{o})	Hemp Fiber (0^{o})

Hemp Composite **Flax Composite** **Hybrid Composite**

Testing of Composites

Mechanical tests are conducted to study the mechanical behavior of composites fabricated. In this work, flexural and impact test is conducted.

Flexural Test

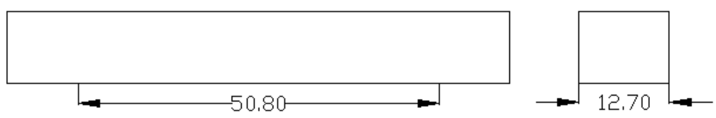

Figure 1: Schematic Diagram of Flexural Test Specimen

Three points bending test which is also known as flexural test is used to find the maximum bending strength of the composite laminate. The sample is prepared as per ASTM D790 as shown in the figure 1. The two ends are supported at the base and the load is applied at the center of the composite specimen and the corresponding breaking load is noted and the graph is generated.

Hardness Test

Rockwell Hardness test is performed to find the hardness of the composite. The specimen is indented with the hardened steel ball. When the maximum load is reached and equilibrium position is achieved, the external load is removed and the corresponding reading is taken as the hardness value.

RESULTS AND DISCUSSIONS

Result of Flexural Test

Table 2shows the result of a Flexural test of various categories of composites made from hemp and flax fibers. The flexural test has been carried out with three point bending machine and the corresponding graphs have been plotted. From the graphs plotted, the ultimate flexural strength of category I recorded high value of 88.26MPa when compared to other categories II and III. This is due to the presence of hemp fiber, which is strong and durable. It absorbs more loads for bending while compared to other categories. The figure 2 shows the consolidated results of ultimate flexural strength of all categories and samples.

Table 2: Results of Flexural Test

Sl. No.	Category	Samples	Ultimate Flexural strength (N/mm^2)	Average Value (N/mm^2)
1	C1	S1	86.06	88.26
		S2	100.23	
		S3	78.49	
2	C2	S1	22.00	18
		S2	17.00	
		S3	15.00	
3	C3	S1	86.77	86.26
		S2	89.66	
		S3	82.37	

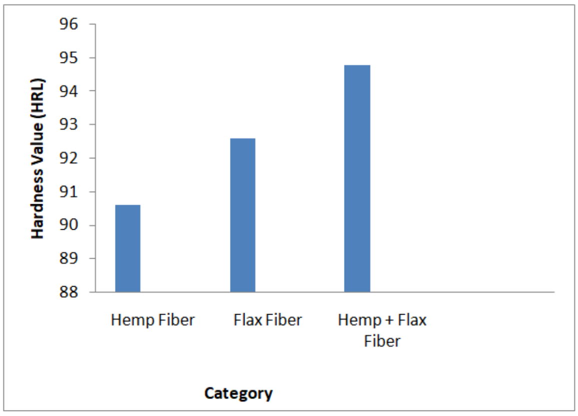

Figure 2: Consolidated Results of Ultimate Flexural Strength (MPa)

Result of Hardness Test

Hardness is the measure of resistance due to indentation. The values of the hardness test corresponding to all categories are tabulated as shown in table 3. It is observed that the hardness of hybrid composite is slightly more than the other two categories. This is because of hybrid composite that contains a combination of flax and hemp fiber. The both

fibers give resistance to indentation and also it has the tendency to resist the penetration. Figure 3 shows a comparison of hardness of 3 categories of composites.

Table 3: Results of Hardness Test

Sl. No.	Category	Hardness Value (HRL)
1	C1	92.6
2	C2	90.6
3	C3	94.8

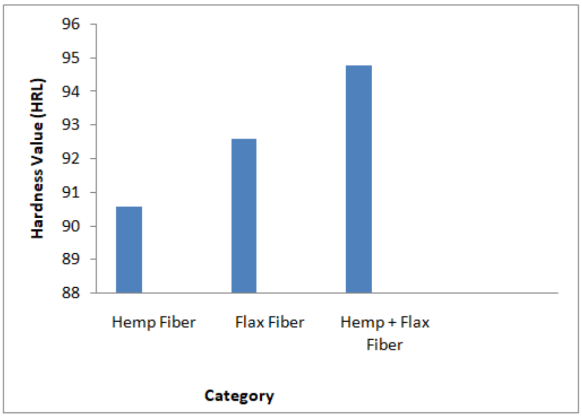

Figure 3: Results of Hardness Test

CONCLUSIONS

In this paper, flexural and hardness behavior of the flax-hemp hybrid composite is studied. It is observed that category I which contains hemp fiber alone has the very good flexural strength while compared with other categories. It is also noted that a hardness of hybrid composite is high as compared to mono-fiber composites of category II and II.

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